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Signed

Dated 17 June 2003



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The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

1. Your reference

DY3015

2. Patent application number

(The Patent Office will fill in this part)

0218777.1

13 AUG 2002

3. Full name, address and postcode of the or of each applicant (underline all surnames)

ROLLS-ROYCE PLC  
65 BUCKINGHAM GATE  
LONDON  
SW1E 6AT

Patents ADP number (if you know it)

3970003

ENGLAND

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

VENTS FOR FLUID SYSTEMS

5. Name of your agent (if you have one)

M A GUNN

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

ROLLS-ROYCE plc  
PATENTS DEPARTMENT  
PO BOX 31  
DERBY  
DE24 8BJ

Patents ADP number (if you know it)

3970064

*3970064*

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
- c) any named applicant is a corporate body.

See note (d)

**Patents Form 1/77**

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Continuation sheets of this form

Description

12

Claim(s)

3

Abstract

1

DM

Drawing(s)

3+3

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

2

Request for preliminary examination and search (Patents Form 9/77)

1

Request for substantive examination (Patents Form 10/77)

1

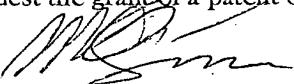
Any other documents  
(please specify)

**DEPOSIT ACCOUNT FEE SHEET**

11.

I/We request the grant of a patent on the basis of this application.

Signature



Date

M A GUNN

12.8.2002

12. Name and daytime telephone number of person to contact in the United Kingdom

P D GEE

01332 249638

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13 AUG 2002

NEWPORT

Statement of inventorship and of  
right to grant of a patent

The Patent Office  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

## 1. Your reference

DY3015

2. Patent application number  
(if you know it)

0218777.1

13 AUG 2002

## 3. Full name of the or of each applicant

ROLLS-ROYCE PLC

## 4. Title of the invention

VENTS FOR FLUID SYSTEMS

5. State how the applicant(s) derived the right  
from the inventor(s) to be granted a patent

BY VIRTUE OF AN AGREEMENT DATED 16 JULY 2002

6. How many, if any, additional Patents Forms  
7/77 are attached to this form? 1  
(see note (c))

7.

I/We believe that the person(s) named over the page (and on  
any extra copies of this form) is/are the inventor(s) of the invention  
which the above patent application relates to.

Signature

Date

M A GUNN

12.8.2002

8. Name and daytime telephone number of  
person to contact in the United Kingdom

P D GEE

01332 249638

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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

JOHN LOVAT BROUGHTON  
1 CHEVIN ALLEY  
MILFORD  
BELPER  
DERBYSHIRE  
DE56 0QE

Patents ADP number (*if you know it*): 8444135 001

Patents ADP number (*if you know it*):

**Reminder**

Have you signed the form?

Patents ADP number (*if you know it*):

**DUPLICATE**VENTS FOR FLUID SYSTEMS

This invention relates to vents for fluid systems. More particularly, but not exclusively, it relates to vents 5 for bearing chambers, for example in gas turbine engines.

Gas turbine engines typically include one or more shafts supported on oil-lubricated bearings. These bearings are housed in bearing chambers, and there are seals between the chamber and the shaft to inhibit the leakage of 10 lubricating oil. It is usually arranged that, under normal operating conditions, the pressure outside a bearing chamber is slightly higher than the pressure within it. This differential pressure ensures that there is a continuous counterflow of air inwards through the seals and 15 oil leakage is avoided. However, under certain transient conditions, the pressures may change so that the differential pressure is reversed. In these circumstances, oil will tend to pass through the seals and out of the bearing chamber.

20 Various types of sealing arrangement are known that attempt to prevent oil leakage. Labyrinth seals generally require a large and heavy buffer system to operate properly; some such systems also incorporate drains to dispose of any oil that does leak, adding further weight 25 and complexity. Carbon seals can operate with a smaller counterflow of air, which may save weight in the buffer system, but they are still prone to allow oil to escape if the differential pressure is reversed.

A separate vent may be provided for the bearing 30 chamber, to allow an outward flow of air, when required, other than through the bearing chamber seals. Examples of such devices are simple vents, with or without restrictors, and spring-loaded valves; but oil can still escape from the

bearing chamber through these devices, and so they do not solve the fundamental problem.

Any oil that does leak out of a bearing chamber may contaminate the core air flow of the engine. When gas 5 turbine engines are installed in aircraft, typically a proportion of the core air flow is taken to supply breathable air for the crew and passengers. The "cabin odour" arising out of this sort of contamination has long been recognised as undesirable. However, in recent years it 10 has become increasingly clear that contaminated cabin air may also represent a serious health and safety hazard.

It is therefore an object of the present invention to provide a simple and compact vent, which will allow air to flow both into and out of the bearing chamber, but which 15 will substantially prevent the leakage of oil from the bearing chamber.

According to one aspect of this invention, a vent for a fluid system includes a chamber through which fluid can flow along either a first flow path or a second flow path, 20 in which the resistance to fluid flow is relatively high when the fluid follows the first flow path and the resistance to fluid flow is relatively low when the fluid follows the second flow path.

Preferably the first flow path is associated with 25 fluid flow in one direction through the chamber, and the second flow path is associated with fluid flow in the opposite direction through the chamber.

Preferably the chamber has two ports, the two ports lying in planes substantially perpendicular to each other.

30 In a particular preferred embodiment of this aspect of the invention, the chamber is substantially cylindrical. Preferably, one of the two ports is arranged to be substantially coaxial with the chamber and the other of the

two ports is arranged to be substantially tangential to the chamber.

The substantially tangential port may have a convergent or convergent-divergent inner profile.

5 An annular wall member may protrude generally axially from the coaxial port into the chamber.

The fluid flow, at least when following the first flow path, may include a component of higher density than the fluid, and the flow of the fluid along the first flow path 10 may act to separate the higher density component from the fluid. The chamber may be extended in an axial direction to receive the higher density component separated from the fluid. Means may be provided to carry the higher density component out of the chamber.

15 The higher density component may comprise a lubricant.

The vent may be a part of a bearing chamber. The vent may be a part of a gas turbine engine.

According to an alternative aspect of the invention, a venting arrangement for a fluid system comprises a first 20 vent and a second vent, the first and second vents being arranged in flow series, in which the first and second vents are so arranged that when fluid flows through the venting arrangement in one direction it follows the first flow path through the chamber of the first vent, and when 25 fluid flows through the venting arrangement in the other, opposite direction it follows the first flow path through the chamber of the second vent.

According to a further alternative aspect of the invention, a venting arrangement for a fluid system 30 comprises a plurality of vents, the vents being arranged in flow series, in which the vents are so arranged that when fluid flows through the venting arrangement in one direction it follows the first flow path through the chamber of each vent in succession, and when fluid flows

through the venting arrangement in the other, opposite direction it follows the second flow path through the chamber of each vent in succession.

The venting arrangement may be a part of a bearing 5 chamber. The venting arrangement may be a part of a gas turbine engine.

The preferred embodiments of all the aspects of the invention described in this specification use a device, known as a vortex throttle or vortex diode, which is well 10 known in the art of fluidics. This device will be described in more detail later in the specification. Those skilled in the art of fluidics will be aware of the distinctions between a vortex throttle and a vortex diode; for the purposes of this specification such distinctions are 15 generally unimportant and for the sake of clarity the term "vortex diode" will be used throughout.

Fluidics is a discipline whose origins lie in attempts to overcome the susceptibility of electronic circuits to interference from electromagnetic radiation. It teaches the 20 construction of circuits, analogous to electrical or electronic circuits, in which a flow of fluid, rather than a flow of electrons, performs the work. Devices such as switches, diodes, amplifiers and so on, familiar in an electrical context, can also be made to work satisfactorily 25 in fluidic circuits. Fluidics has received relatively little attention in recent years, although its principles have been applied (on a larger scale) in fields such as sewage flow control, where the absence of moving parts in fluidic components permits the construction of reliable 30 valves that are not prone to blockage.

Certain embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic sectional view of a vortex diode of known type, showing the air flows in the "low resistance" direction;

Figure 2 is a schematic sectional view taken on the 5 line A-A in Figure 1;

Figure 3 is a schematic sectional view of a vortex diode of known type, showing the air flows in the "high resistance" direction;

Figure 4 is a schematic sectional view taken on the 10 line B-B in Figure 3;

Figure 5 is a schematic representation of a bearing chamber having a vent according to one aspect of the invention;

Figures 6 and 7 are schematic sectional views of two 15 alternative embodiments of a bearing chamber vent according to one aspect of the invention;

Figure 8 is a schematic sectional view of a further alternative embodiment of a bearing chamber vent according to one aspect of the invention;

20 Figure 9 is a schematic representation of a bearing chamber having a venting arrangement according to an alternative aspect of the invention;

Figure 10 is a schematic representation of a bearing chamber having a venting arrangement according to a further 25 alternative aspect of the invention.

Referring first to Figures 1 and 2, a vortex diode 20 of known type comprises structure 22 defining a cylindrical volume 24. Two ducts of circular cross-section are in fluid communication with the cylindrical volume 24. Duct 26 is 30 coaxial with the cylindrical volume 24 and duct 28 is tangential to the cylindrical volume 24.

When fluid flows into the cylindrical volume 24 through the duct 26, as shown by the arrow 30 in Figure 2, it will tend to flow substantially in the manner indicated

chamber, or alternatively be entirely separate from the bearing chamber and mounted separately within the engine.

In normal operation, the pressure in the bearing chamber 50 will be lower than the pressure in the region 62 outside the bearing chamber 50, and so there will be a flow of air from the region 62 into the bearing chamber 50. Air will therefore flow into the vortex diode 56 through the coaxial port 60, and out through the tangential port 54. The air flow through the vortex diode 56 will therefore be substantially as shown by the arrows 30 and 32 in Figures 1 and 2, and the resistance to flow will be relatively low.

It is possible, under certain operating conditions of the gas turbine engine, that the relative pressures in the engine may change such that the pressure in the bearing chamber 50 is higher than the pressure in the region 62. There will then be a flow of air from the bearing chamber 50 into the region 62. Air will therefore flow into the vortex diode 56 through the tangential port 54, and out through the coaxial port 60. The air flow through the vortex diode 56 will therefore be substantially as shown by the arrows 40, 42 and 44 in Figures 3 and 4, and the resistance to flow will be relatively high. It is likely that some oil or similar lubricant will be entrained in the air flow, and (as explained in the discussion of Figures 3 and 4) the swirling motion imparted to the air will tend to urge any such component outwards by centrifugal force, and will thus tend to separate it from the air.

Figures 6 and 7 show two alternative embodiments of the vortex diode used in the vent of Figure 5, in which provision is made to collect oil separated out from the air flow. In the embodiment of Figure 6 the cylindrical volume 24 is extended downward by the addition of an annular volume 64. In Figure 7, the whole of the cylindrical volume 24 is enlarged downward. In use, under the abnormal

conditions described earlier when the air flow is as shown in Figures 3 and 4, any oil separated out from the air flow will collect in the annular volume 64 (of Figure 6) or in the lower part of the enlarged cylindrical volume 24 (of Figure 7). Subsequently, when the air flow returns to normal, as shown in Figures 1 and 2, the separated oil can flow through the conduit 66 back into the duct 28 and subsequently back to the bearing chamber, impelled by the normal flow of air out of the vortex diode 20 through the duct 28 (as shown by arrow 32 in Figure 1). The conduits 66 and 28 may be arranged so that the separated oil will tend to flow back to the bearing chamber under the action of gravity.

Figure 8 shows an alternative embodiment of a vortex diode having a higher resistance to flow in the "low resistance" direction. An annular collar 68 protrudes into the cylindrical volume 24. In addition, the duct 28 is of smaller diameter than in the vortex diode of Figure 1. It will be appreciated, by one skilled in the art, that changes may be made to the protrusion of the collar 68, and to the diameters of the two ducts 26 and 28, so as to tailor the flow resistance of the vortex diode in both directions to suit particular applications.

Figure 9 shows a bearing chamber having a venting arrangement according to an alternative aspect of the invention, which comprises two vortex diodes in flow series. Conduit 52 links the bearing chamber 50 to the tangential port 70 of a first vortex diode 72. Conduit 74 links the coaxial port 76 of the first vortex diode 72 to the coaxial port 78 of a second vortex diode 80. Conduit 82 links the tangential port 84 of the second vortex diode 80 to a region 62 outside the bearing chamber 50.

In normal operation, when the pressure in the bearing chamber 50 is lower than the pressure in the region 62,

there will be a flow of air from the region 62 into the bearing chamber 50. Air will therefore flow into the second vortex diode 80 via its tangential port 84, and out through its coaxial port 78. It will be apparent that the air flow through the second vortex diode 80 will therefore be substantially as shown by the arrows 40, 42 and 44 in Figures 3 and 4, and that the resistance to flow will be relatively high. Furthermore, any oil entrained in the air flow will tend to be separated out by centrifugal force.

5 The air will subsequently flow through the conduit 74 and through the first vortex diode 72, entering through the coaxial port 76 and exiting through the tangential port 70. The air flow through the first vortex diode 72 will therefore be substantially as shown by arrows 30 and 32 in

10 Figures 1 and 2, and the resistance to flow will be relatively low.

15

In the converse case, where the pressure in the bearing chamber 50 is higher than the pressure in the region 62, the flow of air will be from the bearing chamber 20 50 into the region 62. It will be apparent that the flow of air through each of the first and second vortex diodes will be reversed. Consequently the first vortex diode 72 will now offer a relatively high resistance to flow, and any oil entrained in the air flow will tend to be separated out by 25 centrifugal force; the second vortex diode 80 will offer a relatively low resistance to flow. Thus, this venting arrangement will offer a relatively high resistance to flow in both directions, while still permitting the centrifugal separation of any oil entrained in the air flow.

30 It will be appreciated, by one skilled in the art, that this arrangement could be further refined by tailoring the flow characteristics of the first and second vortex diodes (as discussed with reference to Figure 8) to obtain

various combinations of flow characteristics in the two directions

The venting arrangement is shown attached to the side of the bearing chamber. However, it is envisaged that it 5 could equally well be integrated into the structure of the bearing chamber, or alternatively be entirely separate from the bearing chamber and mounted elsewhere within the engine.

It will be appreciated that the two vortex diodes may 10 be arranged differently in relation to each other, provided that their coaxial ports are always linked together, without affecting the operation of the venting arrangement.

Figure 10 shows a bearing chamber having a venting arrangement according to a further aspect of the invention, 15 comprising three vortex diodes arranged in flow series.

Conduit 52 links the bearing chamber 50 to the tangential port 54 of a first vortex diode 56. A conduit 57 links the coaxial port 60 of the first vortex diode 56 to the tangential port 54 of a second vortex diode 56. A 20 further conduit 57 links the coaxial port 60 of the second vortex diode to the tangential port 54 of a third vortex diode 56, in like manner. Conduit 58 links the coaxial port 60 of the third vortex diode 56 to a region 62 outside the bearing chamber 50.

25 Under normal operating conditions, when the pressure within the bearing chamber 50 is less than the pressure in the region 62 outside the bearing chamber 50, air will flow from the region 62, through the conduit 58, then successively through the three vortex diodes 56, entering 30 each in turn through its coaxial port 60 and exiting through its tangential port 54. Within each vortex diode 56, then, the flow of air will be substantially as shown by the arrows 30 and 32 in Figures 1 and 2, and the resistance

to flow through each vortex diode 56 will be relatively low.

In the converse case, when the pressure within the bearing chamber 50 is greater than the pressure in the region 62, air will flow out of the bearing chamber 50, through the conduit 52, then successively through the three vortex diodes 56, entering each in turn through its tangential port 54 and exiting through its coaxial port 60. Within each vortex diode 56, then, the flow of air will be substantially as shown by the arrows 40, 42 and 44 in Figures 3 and 4, and the resistance to flow will be relatively high. In addition, any oil entrained in the air flow can be separated out by centrifugal force in any of the three vortex diodes, thus giving a more effective separation than in the embodiment having only one vortex diode.

The venting arrangement is shown attached to the side of the bearing chamber. However, it is envisaged that it could equally well be integrated into the structure of the bearing chamber, or alternatively be entirely separate from the bearing chamber and mounted elsewhere within the engine.

It will be appreciated that the three vortex diodes may be arranged differently in relation to each other, provided that the ports of the successive vortex diodes are always connected in the manner shown in Figure 10, without affecting the operation of the venting arrangement.

Although this aspect of the invention has been described with reference to three vortex diodes, it will be appreciated by those skilled in the art that other numbers of vortex diodes could equally well be used.

It will be appreciated that it would also be possible for each of the vortex diodes to have different flow

characteristics (as discussed in connection with Figure 8), for example to optimize the oil separation..

CLAIMS

1. A vent for a fluid system, the vent including a chamber through which fluid can flow along either a first flow path or a second flow path, in which the resistance to fluid flow is relatively high when the fluid follows the first flow path and the resistance to fluid flow is relatively low when the fluid follows the second flow path.
2. A vent as claimed in Claim 1, in which the first flow path is associated with fluid flow in one direction through the chamber, and the second flow path is associated with fluid flow in the opposite direction through the chamber.
3. A vent as claimed in Claim 1 or Claim 2, in which the chamber has two ports, the two ports lying in planes substantially perpendicular to each other.
4. A vent as claimed in Claim 3, in which the chamber is substantially cylindrical.
5. A vent as claimed in Claim 4, in which one of the two ports is substantially coaxial with the chamber and the other of the two ports is substantially tangential to the chamber.
6. A vent as claimed in Claim 5, in which the inner profile of the substantially tangential port is convergent.
7. A vent as claimed in Claim 5, in which the inner profile of the substantially tangential port is convergent-divergent.
8. A vent as claimed in Claim 5, in which an annular wall member protrudes generally axially from the coaxial port into the chamber.
9. A vent as claimed in any preceding claim, in which the fluid flow at least when following the first flow path includes a component of higher density than the fluid and the flow of the fluid along the first flow path acts to separate the higher density component from the fluid.

10. A vent as claimed in Claim 9, in which the chamber is extended in an axial direction to receive the higher density component separated from the fluid.
11. A vent as claimed in Claim 9 or Claim 10, in which means are provided to carry the higher density component out of the chamber.
12. A vent as claimed in any of claims 9 to 11, in which the higher density component comprises a lubricant.
13. A bearing chamber including a vent as claimed in any preceding claim.
14. A gas turbine engine including a vent as claimed in any of claims 1 to 12.
15. A vent for a fluid system substantially as described in this specification, with reference to and as shown in Figures 1 to 8 of the accompanying drawings.
16. A venting arrangement for a fluid system, comprising a first vent as claimed in any of claims 1 to 12 and a second vent as claimed in any of claims 1 to 12, the first and second vents being arranged in flow series, in which the first and second vents are so arranged that when fluid flows through the venting arrangement in one direction it follows the first flow path through the chamber of the first vent, and when fluid flows through the venting arrangement in the other, opposite direction it follows the first flow path through the chamber of the second vent.
17. A venting arrangement for a fluid system, comprising a plurality of vents as claimed in any of claims 1 to 12, the vents being arranged in flow series, in which the vents are so arranged that when fluid flows through the venting arrangement in one direction it follows the first flow path through the chamber of each vent in succession, and when fluid flows through the venting arrangement in the other direction it follows the second flow path through the chamber of each vent in succession.

18. A bearing chamber including a venting arrangement as claimed in Claim 16 or Claim 17.
19. A gas turbine engine including a venting arrangement as claimed in Claim 16 or Claim 17.
- 5 20. A venting arrangement for a fluid system substantially as described in this specification, with reference to and as shown in Figure 9 of the accompanying drawings.
21. A venting arrangement for a fluid system substantially as described in this specification, with reference to and
- 10 as shown in Figure 10 of the accompanying drawings.

ABSTRACT

A vent for a fluid system includes a chamber through which fluid can flow along either a first flow path or a second flow path, in which the resistance to fluid flow is relatively high when the fluid follows the first flow path and relatively low when the fluid follows the second flow path. In a preferred embodiment the chamber is substantially cylindrical and has two ports, one of which is substantially coaxial with the chamber and the other of which is substantially tangential to the chamber. The fluid flow, at least when following the first flow path, may include a component of higher density than the fluid, and the flow of the fluid along the first flow path may act to separate the higher density component from the fluid.

(Figures 3 and 4)



FIGURE 1

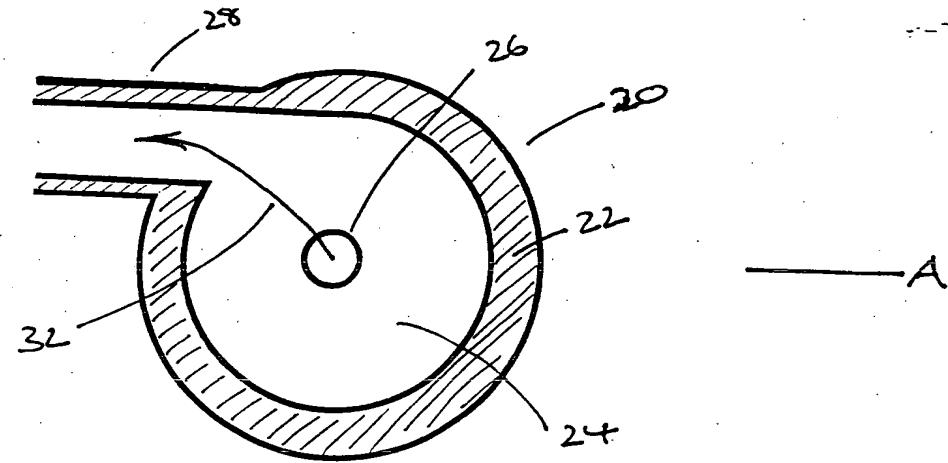


FIGURE 2

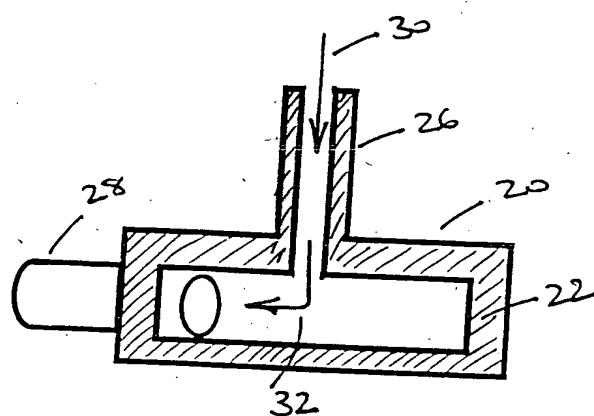


FIGURE 3

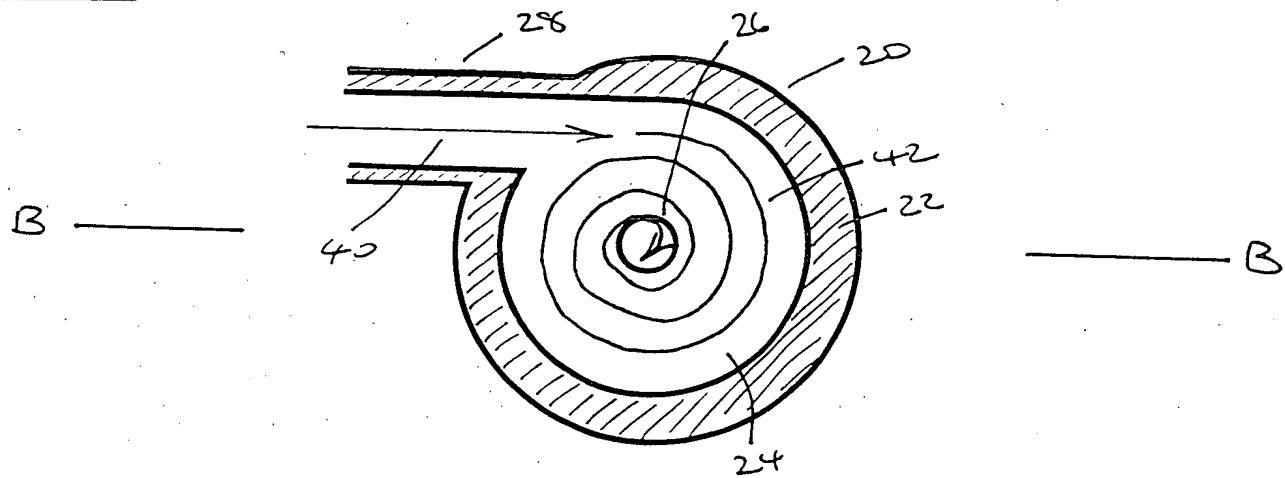


FIGURE 4

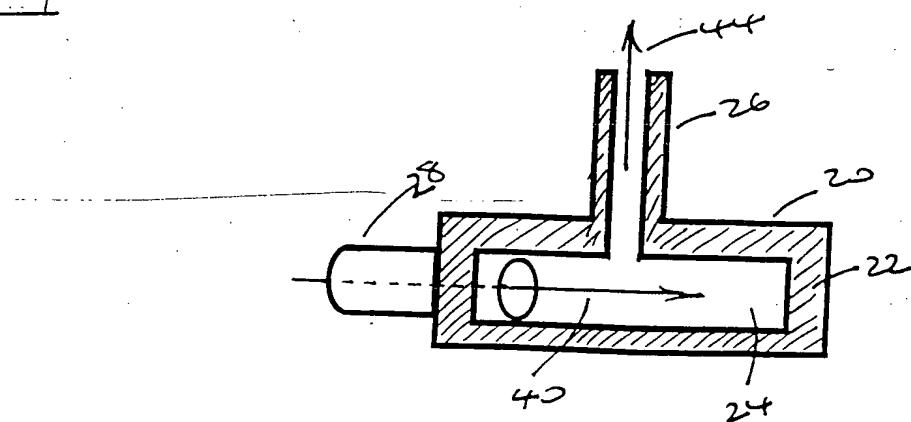




FIGURE 5

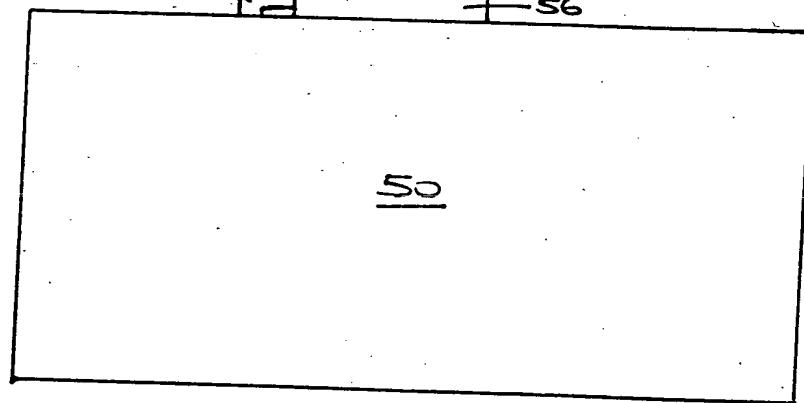
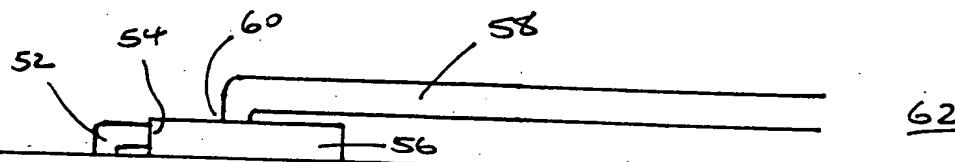


FIGURE 6

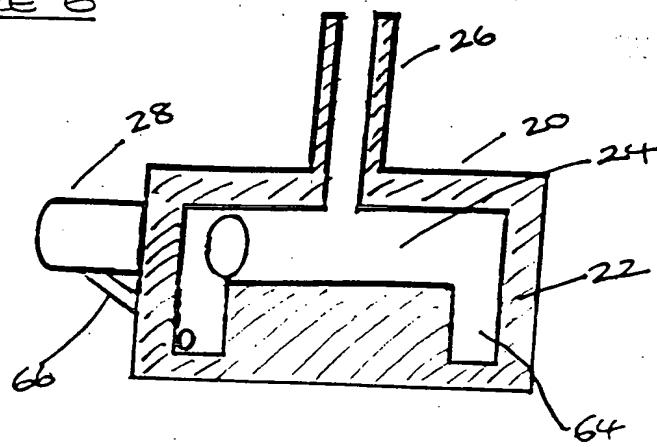


FIGURE 7

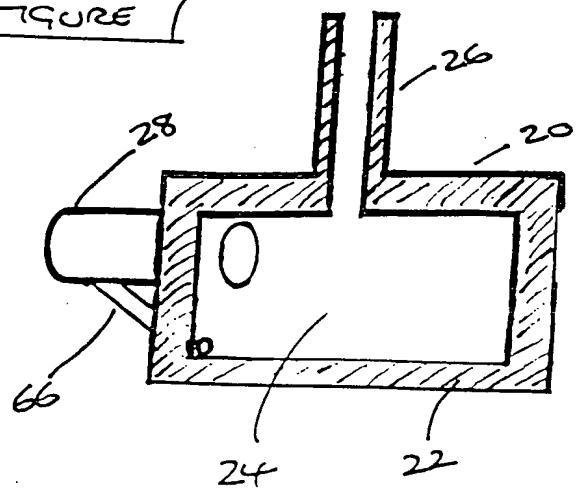


FIGURE 8

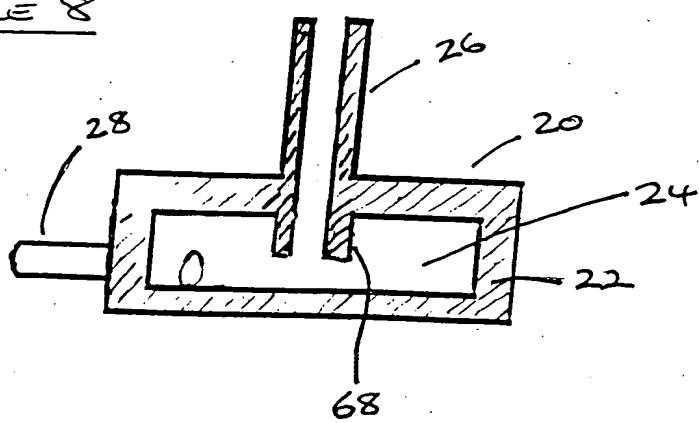




FIGURE 9

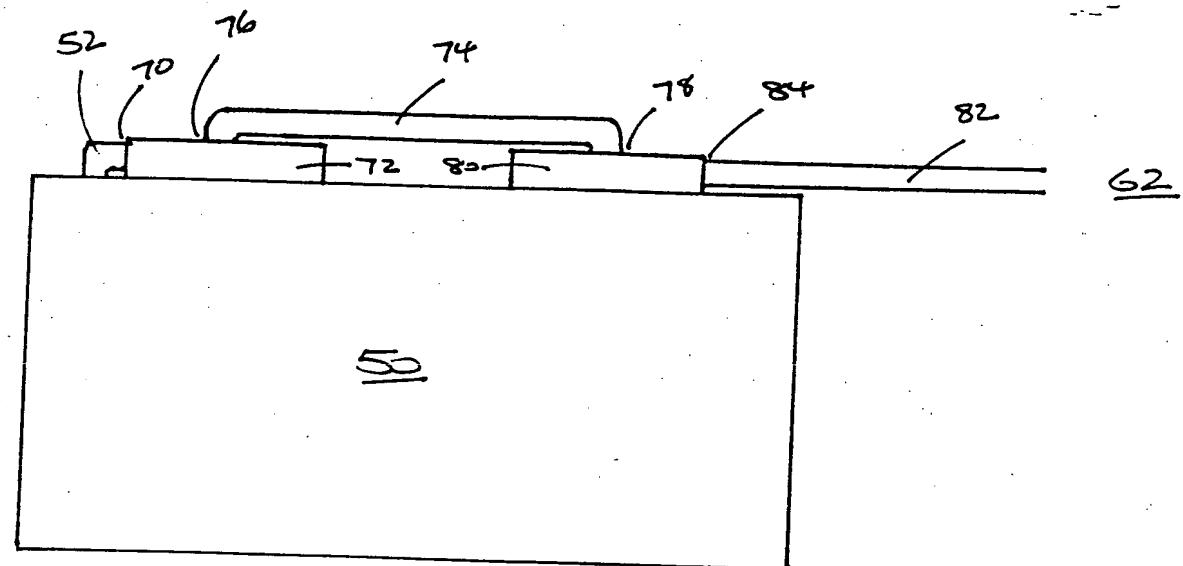


FIGURE 10

